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Growth & Environmental Management
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Analysis:

The contracted work was completed and received by the County on March 3, 2004. A copy of the table of contents from the Final Report, Evaluation of the Treatment Performance for Thomasville Road Stormwater Management Facility No.4 is included in Attachment #2. The main findings and recommendations of the report are set forth below.

1. Proposed Stormwater Management Facility No.4 Monitoring Plan

   Dr. Harper has recommended that a tipping bucket rain gage and automated water level meter be installed at the location of the stormwater facility. These two instruments will allow the County to precisely determine the amount of rainfall in the drainage basin, the amount of runoff therefrom, and the rate of recovery of the pond's storage volume. This information alone can be used to determine whether the facility is in compliance with Ordinance No. 00-31. County staff concurs with Dr. Harper's recommendation. The cost for equipment and installation is **$6,600 with an annual operation cost of $3,772.**

2. Dr. Harper's Peer Review of the County's Analysis of the Stormwater Management Facility No.4's Performance at Build-Out

   Both County staff and Dr. Harper were in agreement that for a stormwater facility to comply with Ordinance 00-31 under built-out conditions, it would need to retain (i.e. not discharge) 75.6 percent of all the post-development runoff coming to the facility over a 40.5 year period.

   County staff determined that 80.2 percent of the post-development runoff to the existing Stormwater Facility No.4 would be retained. Dr. Harper, after adding several refinements to the computer model developed by the County, determined that 85.3 percent of all the post-development runoff would be retained by the pond as now constructed. Thus both staff and Dr. Harper have found that Stormwater Management Facility No.4 will exceed the performance required by Ordinance No.00-31. However, the model indicates that, as an annual average, the facility can be expected to discharge just over three (3) times per year with a volume of approximately 10.5 acre-feet during each event. These discharges are likely to occur following extended rainfall events rather than in response to an individual storm.

3. If Necessary, Recommend Ways to Improve Stormwater Management Facility No.4's Performance

SECTION 1

INTRODUCTION

This report provides a summary of work efforts performed by Environmental Research and Design, Inc. (ERD) for Leon County (County) to evaluate the water quality treatment performance of the Thomasville Road Stormwater Management Facility No. 4, also referred to as the Lauder Pond or SWMF No. 4. The Pond is located in an unincorporated portion of Leon County, referred to as the Bradfordville area, approximately 8 miles northeast of the city of Tallahassee. The Pond is located southwest of the intersection of Thomasville Road and County Road 154, which is designated as Bannerman Road west of Thomasville Road and as Bradfordville Road east of Thomasville Road. A general location map for SWMF No. 4 is given in Figure 1-1.

Stormwater Management Facility No. 4 is a 12.2-acre wet detention pond which receives stormwater runoff from a 119.53-acre watershed area. Approximate delineations of the basin areas discharging to SWMF No. 4 are indicated on Figure 1-1, based upon information provided to ERD by the County. When runoff inputs into SWMF No. 4 exceed the design retention capacity of the system, discharges from the pond may occur through an outfall structure into the southwest corner of Lake McBride. Under existing conditions the majority of the 119.53-acre watershed discharging to SWMF No. 4 is either undeveloped or developed with relatively low-intensity land use types. Based upon records maintained by the County, no discharges have occurred from SWMF No. 4 into Lake McBride under existing conditions.

During 1998 to 2000, ERD performed a study for Leon County to evaluate existing water quality characteristics of waterbodies in the Bradfordville area and to evaluate the assimilative

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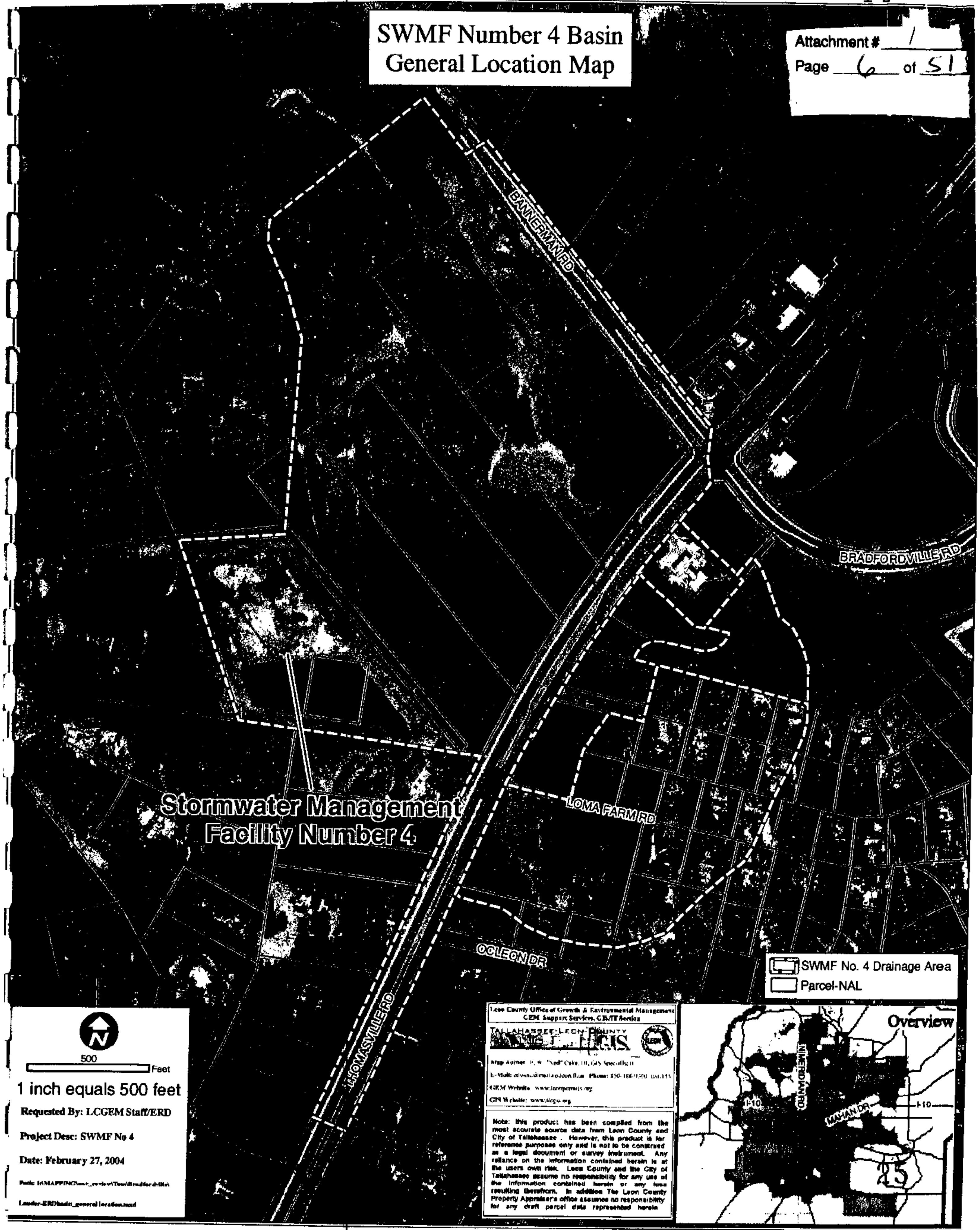

Figure 1-1. Location Map for Stormwater Management Facility No. 4.

capacity of the area lakes for inputs of stormwater pollutants under existing and future land use conditions. A report was issued by ERD in May 2000, titled "Bradfordville Stormwater Study", which summarized the results of the work efforts performed by ERD and recommended alternative stormwater design criteria to achieve an overall goal of no net increase in loadings to waterbodies in the Bradfordville area as a result of future development compared with loadings discharging to the lakes under existing conditions. To achieve the overall goal of no net increase in loadings following development, ERD recommended a treatment standard for the Bradfordville area which required dry retention for runoff with a treatment volume equivalent to 4 inches of runoff over the impervious areas of the project. The standard was subsequently adopted by the Leon County Board of County Commissioners and is commonly referred to as the "Bradfordville Stormwater Rule" or "4-inch Standard".

Since SWMF No. 4 was designed and constructed prior to implementation of the Bradfordville Stormwater Rule, concern has been raised by various groups and individuals that this facility may not meet the Bradfordville Stormwater Rule and provide the required 4 inches of retention for impervious areas discharging to the pond. A spreadsheet model of the basin hydrology and overall pond performance was developed by Leon County to address this issue. During July 2003, ERD entered into an agreement with Leon County to perform a review of the pond performance evaluation performed by Leon County to ensure compliance with the overall objectives of the Bradfordville Stormwater Rule.

The specific objectives of the work efforts performed by ERD are to: (1) evaluate SWMF No. 4 for compliance with the current Bradfordville Stormwater Rule; (2) propose a monitoring plan for SWMF No. 4 to evaluate the hydraulic performance of the system; (3) propose methods to ensure and enhance the performance of SWMF No. 4; and (4) propose emergency methods to avoid non-compliance of SWMF No. 4.

The results and conclusions reached by ERD during this evaluation are based in part upon ERD's basic familiarity with the Bradfordville area, Lake McBride, and the Bradfordville Stormwater Study. In addition, information and documents were provided to ERD by Leon County, including: (1) information on land use and hydrologic characteristics of the sub-basin area discharging to SWMF No. 4; (2) area, stage, and volume relationships for SWMF No. 4; (3) records collected by Leon County of the hydraulic performance of the pond during inter-event dry periods; (4) a drainage basin map for the pond; (5) aerial photographs of the pond including delineated sub-basin areas; (6) drainage and piping plans for Thomasville Road and Bannerman Road; (7) soil borings in the vicinity of the stormwater management facility; (8) daily rainfall records from the Tallahassee airport from 1959 to 1998; and (9) a copy of a continuous simulation model for SWMF No. 4 produced by Leon County in Excel format.

This report is divided into four separate sections for presentation of the work efforts performed by ERD. Section 1 contains an introduction to the report and provides a summary of the overall work efforts performed by ERD. Section 2 contains an evaluation of the performance efficiency of the pond and recommends a monitoring plan which would provide additional information on the overall performance of the system. Methods to enhance pond performance are evaluated in Section 3. A discussion of emergency measures to avoid non-compliance of the facility is given in Section 4.

SECTION 2

EVALUATION OF POND PERFORMANCE EFFICIENCY

An evaluation of the anticipated performance efficiency of SWMF No. 4 was conducted by ERD under proposed future land use conditions and various performance enhancement options. A basic hydrologic model for the pond, provided by Leon County, was also reviewed by ERD, and modifications were made to improve the overall accuracy of the predictive model. The results of these analyses are summarized in the following sections.

2.1 Performance Efficiency Evaluations

2.1.1 Pond Characteristics

A summary of morphometric characteristics of SWMF No. 4 is given in Table 2-1 based upon information provided by the County. In general, the pond consists of two separate zones. The southwest portion of the pond is primarily a deep sump area which is approximately 3.4 acres in size and 6 ft in depth. This area maintains a permanent pool of standing water throughout most of the year. Above this zone the pond spreads out into a broad shallow area which reaches 8.74 acres, including the 3.4-acre sump area. The bottom of the sump area is set at elevation 154.0 ft (NGVD) with an overflow weir set at an elevation of 163.28 ft (NGVD). When the water level increases to a height in excess of 163.28 ft, discharges to Lake McBride begin to occur. The total pond volume contained within the basin, below the outflow elevation of 163.28 ft, is approximately 45.18 ac-ft.

TABLE 2-1

MORPHOMETRIC CHARACTERISTICS OF SWMF NO. 4

(Source: Leon County)

STAGE (El, ft NGVD)	SURFACE AREA (acres)	POND VOLUME (ac-ft)
154.00	2.92	0.00
157.00	3.15	9.11
159.99	3.39	18.88
160.00	7.20	18.94
161.00	7.69	26.38
162.00	8.18	34.32
163.00	8.67	42.74
163.28[1]	8.74	45.18

1. Top of overflow weir to Lake McBride

2.1.2 Drainage Basin Characteristics

A summary of potential future land use within the SWMF No. 4 drainage basin is given in Table 2-2, based upon information provided by Leon County. Estimates of future land use are based upon complete build-out conditions within the SWMF No. 4 basin assuming maximum development intensity and impervious areas. Assumptions utilized for development of build-out conditions are indicated on Figure 2-1. For summary purposes, future land use is divided into four separate areas. Area 1 includes existing Leon County parcels which will be developed into commercial property, a school, a small park, and an addition to SWMF No. 4. A future church parcel and residential areas north of SWMF No. 4 are also planned. For evaluation purposes, it is assumed that the commercial and church parcels will be developed with the maximum amount of impervious area allowed, currently 40% within the Bradfordville area. Parcels owned or controlled by Leon County are located primarily west of Thomasville Road.

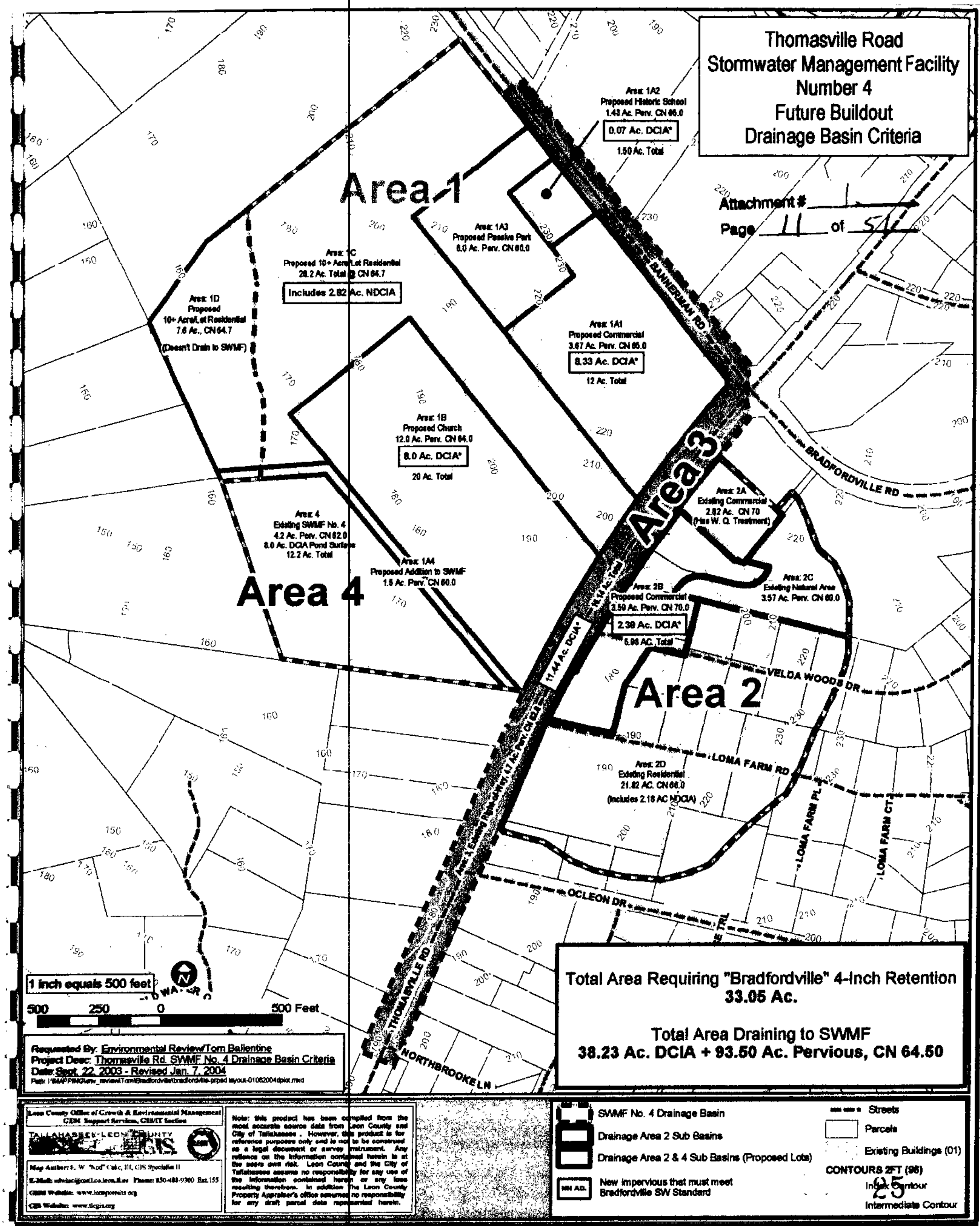

Figure 2-1. Assumptions Used for Development of Build-Out Conditions.

TABLE 2-2

FUTURE LAND USE WITHIN THE
SWMF NO. 4 DRAINAGE BASIN

LOCATION	BASIN AREA (acres)	DCIA (acres)	TOTAL IMPERVIOUS AREA (acres)	PERVIOUS (Non-DC IA) AREA (acres)	PERVIOUS (Non-DCIA) CN	NEW IMPERVIOUS REQUIRING TREATMENT (acres)
Area 1 - Leon County Parcels 1A-1: Commercial Parcel (Impervious is 40% of total area 1A)	12.0	8.33	8.33	3.67	65.0	8.33
1A-2: School Parcel	1.5	0.07	0.07	1.43	65.0	0.07
1A-3: Park Parcel	6.0	0.00	0.00	6.00	60.0	0
1A-4: Addition to SWMF No. 4	1.5	0.00	0.00	1.50	60.0	0
1B: Church Parcel	20.0	8.00	8.00	12.00	64.0	8.0
1C: Residential Area North of SWMF (2.82 ac new NDCIA, pervious @ CN 61)	28.2	0.00	2.82	28.20	64.7	2.82
Area 1 Draining to SWMF No. 4:	**69.20**	**16.40**	**19.22**	**52.8**	**64.0**	**19.22**
Area 2: Parcels East of Thomasville Road 2A: Chevron Station (existing)	2.82	0.70	0.70	2.12	70.0	0
2B: Commercial Lots	5.98	2.39	2.39	3.59	70.0	2.39
2C: Natural Area	3.57	0.00	0.00	3.57	60.0	0
2D: Existing Residential (2.18 ac NDCIA, pervious @ CN 62.4)	21.82	0.00	2.18	21.82	66.0	0
Area 2 Draining to SWMF No. 4:	**34.19**	**3.09**	**5.27**	**31.1**	**67.6**	**2.39**
Area 3: Bannerman and Thomasville Roads	16.14	11.44	11.44	4.7	62.0	11.44
TOTAL TO SWMF NO. 4:	**119.53**	**30.93**	**35.93**	**88.60**	**–**	**33.05**
Area 4: SWMF No. 4	12.2	8.0	8.0	4.2	62.0	0

Area 2 consists of parcels east of Thomasville Road and includes an existing Chevron Station, with stormwater treatment based on pre-Bradfordville standards, along with anticipated commercial, residential, and natural areas. Similar to the assumptions utilized for Area 1, the proposed commercial areas are assumed to have an impervious percentage of 40% which is the maximum allowed under zoning regulations within the Bradfordville area. Area 3 includes the right of way and roadway areas associated with Bannerman and Thomasville Roads. Information on the percentage of directly connected impervious areas (DCIA) is also included in Table 2-3, along with estimates of pervious areas and curve numbers based upon existing soil types. Area 4 includes the 12.2-acre SWMF No. 4 facility assuming 8.0 acres of water surface and 4.2 acres of upland area.

According to information contained in the Leon County Soil Survey, soils in the SWMF No. 4 basin are primarily classified in Hydrologic Soil Groups (HSG) A or B. Soils designated in HSG A or B include sandy soils with good surficial permeability and a low runoff potential. Hydrologic characteristics for soil types are included in modeling used to estimate runoff volumes generated from the SWMF No. 4 drainage basin under both existing and future conditions.

2.1.3 Required Removal Efficiency Based on 4-Inch Rule

An evaluation was performed to determine the required retention efficiency for SWMF No. 4 based upon the 4-inch Bradfordville Standard. The Standard requires dry retention treatment with a volume equivalent to 4 inches over the percentage of impervious area within the basin. As seen in Table 2-2, the drainage basin discharging to SWMF No. 4 contains 33.75 acres of impervious area. Approximately 0.70 acres of this impervious area, associated with the Chevron Station west of Thomasville Road, have an existing stormwater treatment facility. However, since the existing Chevron Station facility was designed and constructed prior to implementation of the 4-inch Bradfordville Rule, the impervious area for this parcel is not included in the impervious area requiring stormwater treatment at the 4-inch standard, leaving a total of 33.05 acres of impervious area which must meet the 4-inch standard. Based upon the impervious area of 33.05 acres, retention of 4 inches of runoff over this area is equivalent to a retention volume of 11.02 ac-ft.

A separate analysis was conducted to evaluate the percentage of the annual runoff volume retained within the SWMF No. 4 drainage basin based upon a theoretical retention pond volume of 11.02 ac-ft. An evaluation of the percentage of annual runoff volume retained was performed by ERD based upon daily rainfall records at the Tallahassee Airport for the 40-year period from January 1, 1959 to December 31, 1998. A complete listing of daily rainfall recorded over this period is given in Appendix A.

The anticipated runoff volumes generated by daily rain events were calculated for post-development conditions, based upon the hydrologic characteristics for the SWMF No. 4 drainage basin summarized in Table 2-2. The runoff volume for each rainfall event is calculated by adding the rainfall excess from the non-DCIA portion of a given parcel to the rainfall excess created from the DCIA portion of the same parcel. Rainfall excess from the non-DCIA areas is calculated using the equations shown below:

$$nDCIA\ CN = \frac{CN * (100 - Imp) + 98\ (Imp - DCIA)}{(100 - DCIA)}$$

$$Soil\ Storage,\ S = \left(\frac{1000}{nDCIA\ CN} - 10\right)$$

$$Q_{nDCIA_i} = \frac{(P_i - 0.2S)^2}{(P_i + 0.8S)}$$

where:

CN	=	curve number for pervious area
Imp	=	percent impervious area
$DCIA$	=	percent directly connected impervious area
$nDCIA\ CN$	=	curve number for non-DCIA area
P_i	=	total rainfall for rainfall event (i)
Q_{nDCIAi}	=	rainfall excess for non-DCIA for rainfall event (i)

For rainfall events where P_i is less than 0.10, the rainfall excess (Q_{nDCIAi}) is assumed to be zero. For the DCIA portion, rainfall excess is calculated using the following equation:

$$Q_{DCIA_i} = (P_i - 0.1)$$

When P_i is less than 0.1, Q_{DCIAi} is equal to zero.

The total runoff volume for a rainfall event is calculated using the following equation:

$$RO_i = \left[[Q_{nDCIAi} \ x \ A \ x \ (100 - DCIA)] + [Q_{DCIAi} \ x \ A \ x \ DCIA] \right] x \ \frac{1}{12} \ x \ \frac{1}{100}$$

where:

A	=	area for specific land use (ac)
RO_i	=	runoff volume for rainfall event (i)

The sum of all the runoff volumes (RO_i) for each rainfall event in a given year is equal to the total annual rainfall volume for a given parcel. The weighted basin "C" value can be calculated using the following equation:

$$C \ Value = \frac{Generated \ Runoff \ Volume \ (ac - ft/yr)}{Area \ x \ Total \ Annual \ Rainfall \ (inches)} \ x \ \frac{12 \ inches}{1 \ ft}$$

Runoff volumes in excess of 11.02 ac-ft for daily rain events were summed to provide an estimate of the allowable runoff discharge from the SWMF No. 4 basin while still meeting the Bradfordville Stormwater Rule. For purposes of this evaluation, it is assumed that the full retention volume is available at the start of each rain event, representing the maximum possible removal effectiveness of the pond system.

A summary of the results of these evaluations is given in Table 2-3. If the first 11.02 ac-ft of runoff is retained for each event, assuming that the full retention volume is available at the start of each rain event, approximately 75.6% of the annual runoff volume will be retained within the system. The remaining 24.4% will be an allowable discharge from the facility into the ultimate receiving waterbody. Therefore, to meet the Bradfordville 4-inch rule, SWMF No. 4 must provide retention equivalent to 75.6% of the runoff volume which enters the facility on an annual average basis.

TABLE 2-3

ESTIMATED RUNOFF VOLUME RETENTION FOR THE SWMF NO. 4 POND BASED ON THE BRADFORDVILLE 4-INCH RULE

PARAMETER	NUMBER OF RAIN EVENTS	VOLUME (ac-ft)	PERCENT OF TOTAL (%)
1. Runoff volume retained with 11.02 ac-ft retention	14,624	7325.6	75.6
2. Runoff volume in excess of 11.02 ac-ft retention	194	2365.3	24.4
3. Total runoff volume	14,818	9690.9	100.0

2.1.4 Estimated Performance Efficiency of SWMF No. 4

2.1.4.1 Leon County Model

An Excel spreadsheet model was developed by Leon County which provides a continuous simulation of inputs and losses for the SWMF No. 4 based upon the daily rainfall records collected at the Tallahassee Airport for the period from January 1, 1959 to December 31, 1998. Runoff inputs into the pond are calculated for the 119.53-acre drainage basin area using the basic methodology for calculation of runoff volumes outlined in Section 2.1.3. The model also considers the morphometry of SWMF No. 4 based upon the surface area and volume relationships presented in Table 2-1. Losses from the pond are assumed to occur as a result of the combined processes of infiltration and evaporation based upon a constant loss rate of 1.05 inches per day.

A general representation of the model developed by Leon County is given below:

Daily Ending Pond Stage =

Beginning Pond Stage + Runoff Inputs – (Evaporation + Infiltration)

The pond stage at the end of any given day is equal to the pond stage at the beginning of the day, plus calculated runoff inputs, minus water volume metric losses from the combined effects of infiltration and evaporation. The resulting pond stage at the end of the day becomes the beginning pond stage for calculations performed on the next daily simulation.

A summary of model parameters for the Leon County daily simulation model for SWMF No. 4 is given in Table 2-4. The model assumes that the drainage basin discharging to SWMF No. 4 contains 93.5 acres of pervious areas and 38.23 acres of new directly connected impervious area (DCIA), including pervious and impervious areas contained within SWMF No. 4. The percolation rate of SWMF No. 4, which includes both evaporation and infiltration, is assumed to be a constant value of 1.05 inches per day. No pre-treatment is assumed within the basin for runoff prior to entering the pond. Based upon these input parameters, the Leon County model calculates that the pond will provide a total retention of approximately 80.2% over the 40-year simulation, with an average pond stage of 160.85 ft. The average pond stage is approximately 2.4 ft below the overflow elevation for the pond.

TABLE 2-4

MODEL PARAMETERS FOR LEON COUNTY DAILY SIMULATION MODEL FOR SWMF NO. 4

MODEL PARAMETERS	VALUE
1. Input Parameters	
Composite Curve Number for Non-DCIA	64.50
Soil Storage	5.48
Initial Abstraction @ 0.2 S	1.10
Acres of Existing (old) DCIA	0.00 acres
Acres of Pervious (to SWMF No. 4)	93.50 acres
"Perc Rate" of SWMF No. 4	1.05 inches/day
Acres of New DCIA	38.23 acres
Pre-Treatment Applied to New DCIA	0.00 inches
Volume of Pre-Treatment Swales	0.000 ac-ft
Recovery Rate of Swales	0.000 ac-in/day
2. Model Output	
Total Retention of Combined System	80.2%
Average Pond Stage	160.85 ft

The daily simulation model developed by Leon County contains several significant conservative assumptions which tend to underestimate the anticipated performance efficiency of the system. First, the simulation is based upon daily rainfall records, and the total rainfall measured during each 24-hour period is assumed to be a single rain event. While this assumption is probably true for the majority of monitored rain events, there will be instances where the reported 24-hour rainfall is comprised of multiple small events which occur during the day. For example, a daily reported rainfall of 1 inch could actually be a result of multiple smaller events which occurred throughout the day. The multiple smaller events may generate little or no measurable runoff when modeled themselves, but when modeled as a single 1-inch event, a significant runoff volume is predicted. Therefore, on some occasions the model developed by the County may over-estimate the actual runoff volume which discharges into SWMF No. 4.

A second conservative assumption inherent in the Leon County model is that the future land use, upon which the runoff model is based, is assumed to be the maximum intensity of development allowed by current zoning codes within the Bradfordville area. Development within all of the Leon County parcels, identified on Table 2-2, is assumed to occur at the maximum allowable impervious area of 40%. However, it is possible that the development may occur at a lower intensity of impervious area. Therefore, this assumption also serves to potentially over-estimate the amount of runoff entering SWMF No. 4.

The estimated percolation rate of 1.05 inches per day utilized by Leon County or SWMF No 4. is based upon observations of water surface drawdown within the pond during periods of no rainfall. These records were generated by Leon County personnel on approximately a daily basis from August 2000 to August 2001. Observations were made of the staff gauge reading at the time of the measurement, along with weather conditions such as temperature and sky conditions. Based upon these field measurements, the average pond drawdown is calculated to be 1.05 inches per day.

2.1.4.2 Revised ERD Model

2.1.4.2.1 Model Assumptions and Modifications

The model developed by Leon County was thoroughly reviewed by ERD with respect to applicability and accuracy for each of the modeled components. Estimation of runoff volumes in the Leon County model is based upon the methodology outlined in Section 2.1.3. This methodology is utilized frequently by ERD for estimation of runoff volumes for drainage basin evaluations. This basic methodology is similar to the methodology utilized in the EPA SWIM model which is widely used throughout the United States. Therefore, the algorithms used for estimation of runoff volumes appear to be appropriate, and no modifications were made by ERD.

The second major component of the Leon County model is the estimation of the water removal rate from the pond due to the combined effects of infiltration and evaporation. As indicated previously, the average percolation rate of 1.05 inches per day is based upon field measurements performed within the pond by Leon County personnel from August 2000 to August 2001. However, to provide the most accurate prediction, it may be best to separate the processes of infiltration and evaporation since evaporation can vary substantially throughout the year.

An analysis of observed drawdown data for SWMF No. 4 was prepared by Moore Bass Consulting, Inc. during September 2001 based upon recorded stage information for the pond from August 2000 to August 2001. Continuous periods with no recorded rainfall were evaluated, and the beginning and ending water elevations were used to calculate the average water loss rate over the period of evaluation. The resulting average infiltration rates included the combined effects of infiltration and evaporation.

A modified version of the evaluation performed by Moore Bass Consulting is given in Table 2-5. Information on starting and ending elevations within the pond are included along with the number of days over which the drawdown was measured. Mean water depth within the pond is also provided for evaluation purposes. The combined pond losses, reflecting both infiltration plus evaporation, are also included in terms of inches per day.

Attachment # 1
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TABLE 2-5

EVALUATION OF DRAWDOWN CHARACTERISTICS FOR SWMF NO. 4 DURING PERIODS OF NO RAINFALL

ELEVATION		MEAN WATER DEPTH (ft)	TIME (days)	INFILTRATION + EVAP (inches/day)	MONTH	MONTHLY LAKE EVAP (inches/month)	INFLITRATION (inches/day)
START	END						
155.58	155.44	1.510	4.23	0.397	2	2.43	0.310
155.35	155.32	1.335	0.91	0.394	2	2.43	0.307
155.33	155.16	1.245	4.85	0.421	2	2.43	0.334
156.04	155.85	1.945	3.94	0.579	3	3.98	0.437
156.82	156.30	2.560	10.10	0.618	5	5.25	0.431
161.40	160.80	7.100	5.10	1.411	6	4.97	1.234
159.77	159.59	5.680	2.05	1.053	7	5.16	0.868
159.92	159.78	5.850	2.03	0.826	7	5.16	0.641
157.97	157.81	3.890	2.00	0.960	8	4.57	0.797
160.07	159.68	5.875	4.16	1.125	8	4.57	0.962
161.06	160.89	6.975	1.77	1.152	8	4.57	0.989
160.65	160.38	6.515	2.90	1.116	8	4.57	0.953
157.72	157.37	3.545	4.02	1.045	9	4.07	0.900
158.02	157.72	3.870	2.93	1.227	9	4.07	1.082
159.03	158.10	4.565	8.20	1.361	9	4.07	1.216
157.50	156.44	2.970	10.94	1.163	10	3.48	1.039
155.67	155.31	1.490	6.08	0.710	11	2.56	0.619
155.57	155.50	1.535	1.23	0.681	11	2.56	0.590
155.82	155.46	1.640	8.00	0.540	12	2.04	0.467

Evaporation data for the Tallahassee area was obtained by ERD based upon monthly evaporation records measured at the Lake City Meteorological Station, which is the closest long-term evaporation station to the Tallahassee area. Monthly lake evaporation data for each month is also provided on Table 2-5. The evaporation data is divided by the number of days in each month to obtain an estimate of average evaporation losses in terms of inches per day. These values are subtracted from the combined drawdown resulting from infiltration plus evaporation to obtain an estimate of losses due to infiltration only. The estimated infiltration values are summarized in the final column of Table 2-5.

The relationship between pond water elevation and calculated infiltration rates is indicated on Figure 2-2. The data suggest a curvilinear relationship which provides a best fit to a logarithmic function. The R-square value for this relationship is 0.65, indicating that the relationship between water depth and infiltration explains 65% of the variability in the measured data. The relationship presented in Figure 2-2 is used by ERD in the modified model to calculate pond infiltration as a function of elevation above the pond bottom.

The Leon County model was modified by ERD to include separate estimates of infiltration and evaporation. Evaporation is assumed to vary on a monthly basis, based upon the values summarized in Table 2-5. Infiltration losses are calculated based upon water depth within the pond using the relationship summarized in Figure 2-2.

The final difference between the model developed by Leon County and the modified ERD model involves estimation of runoff generated by the pond area itself. The Leon County model assumes a constant surface area for water within the pond and a corresponding constant pervious area adjacent to the pond. The modified ERD model uses the actual pond area at the time of the rain event to calculate direct precipitation inputs upon the pond. Runoff generated from the pervious areas adjacent to the pond is calculated in a manner similar to that used for estimation of runoff from other portions of the watershed area.

2.1.4.2.2 Model Results

The modified ERD model was used to calculate overall pond performance over the 40-year period of record from 1959 to 1998. A graphical summary of the results of this simulation is given in Figure 2-3 for the period from 1958 to 1970, in Figure 2-4 for the period from 1970 to 1980, in Figure 2-5 for the period from 1980 to 1990, and in Figure 2-6 for the period from 1990 to 1998. Estimates of pond elevation are provided along with actual rainfall records measured over the 40-year period. Whenever the pond elevation reaches the outfall stage of 163.28 ft, the

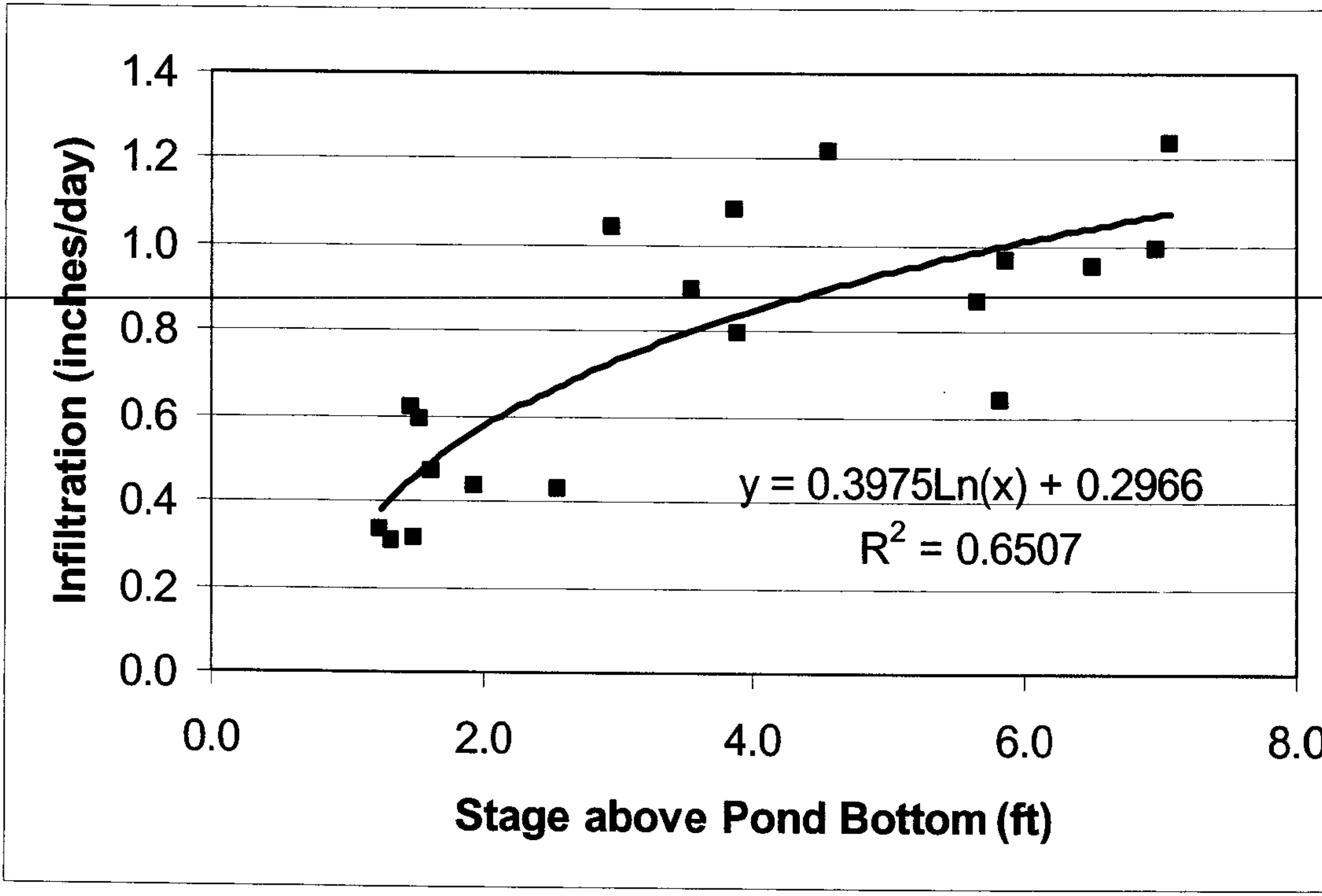

Figure 2-2. Relationships Between Pond Water Elevation and Infiltration Rates.

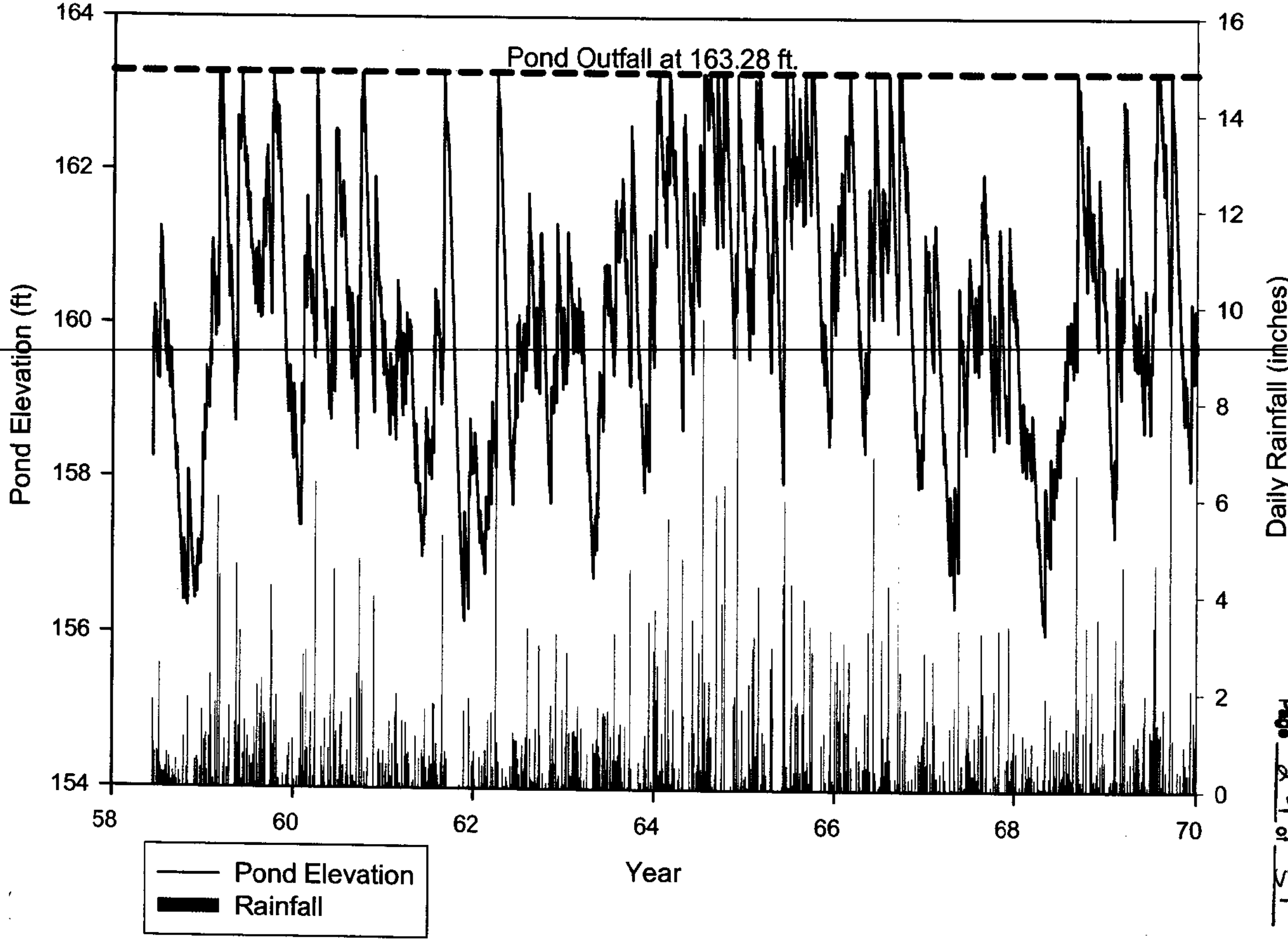

Figure 2-3. Model Simulated Water Elevations for SWMF No. 4 from 1958 to 1970.

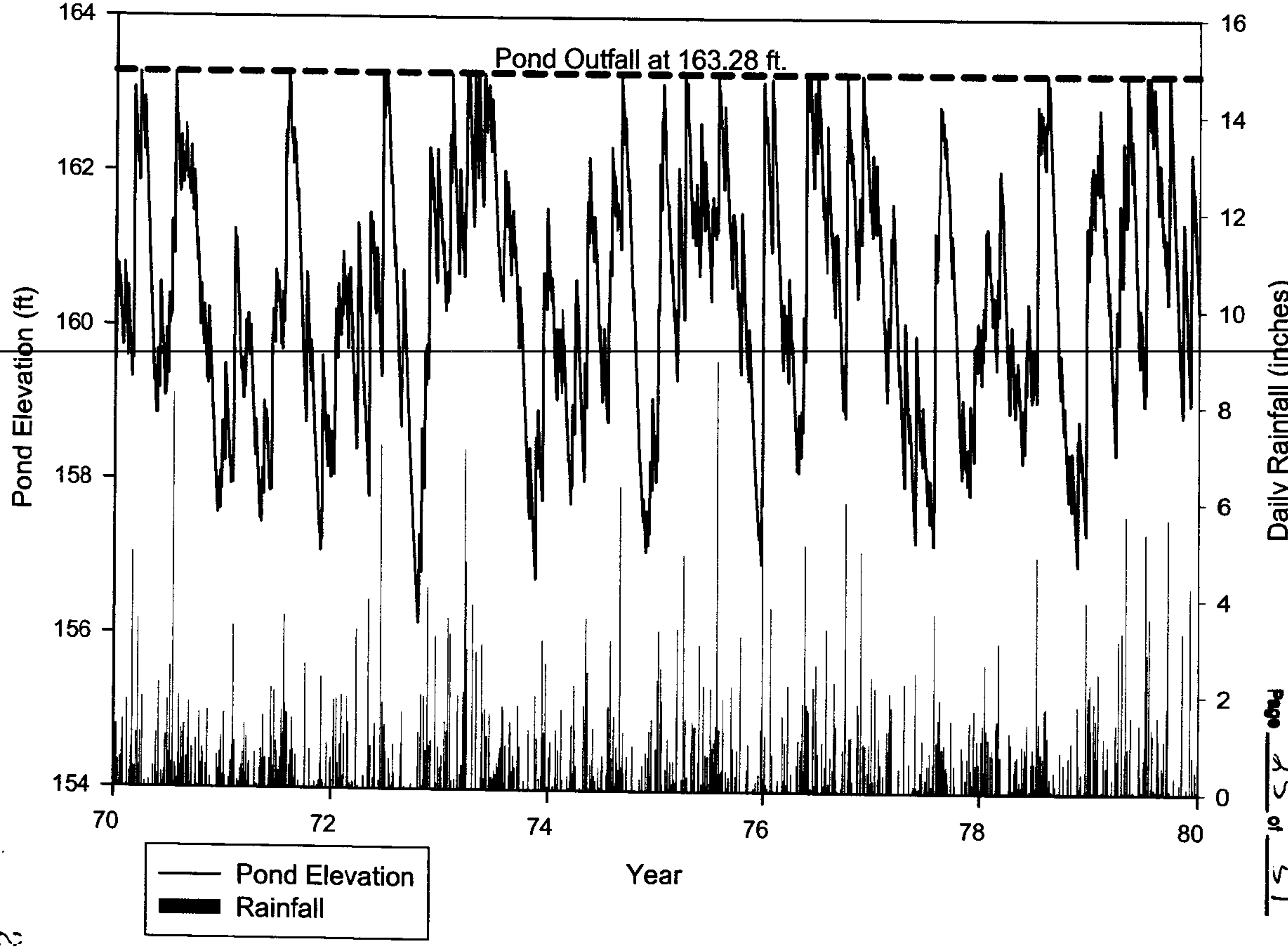

Figure 2-4. Model Simulated Water Elevations for SWMF No. 4 from 1970 to 1980.

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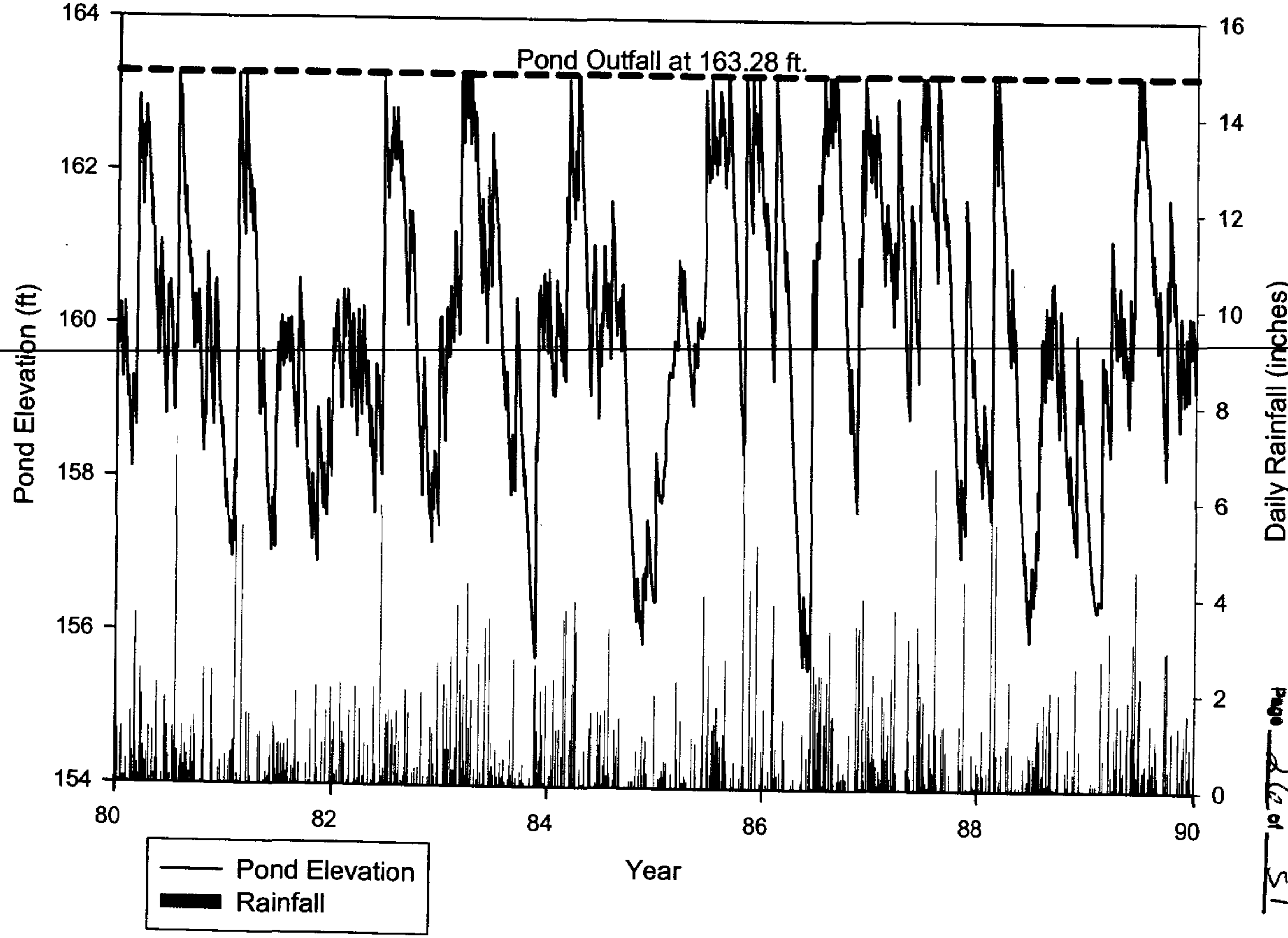

Figure 2-5. Model Simulated Water Elevations for SWMF No. 4 from 1980 to 1990.

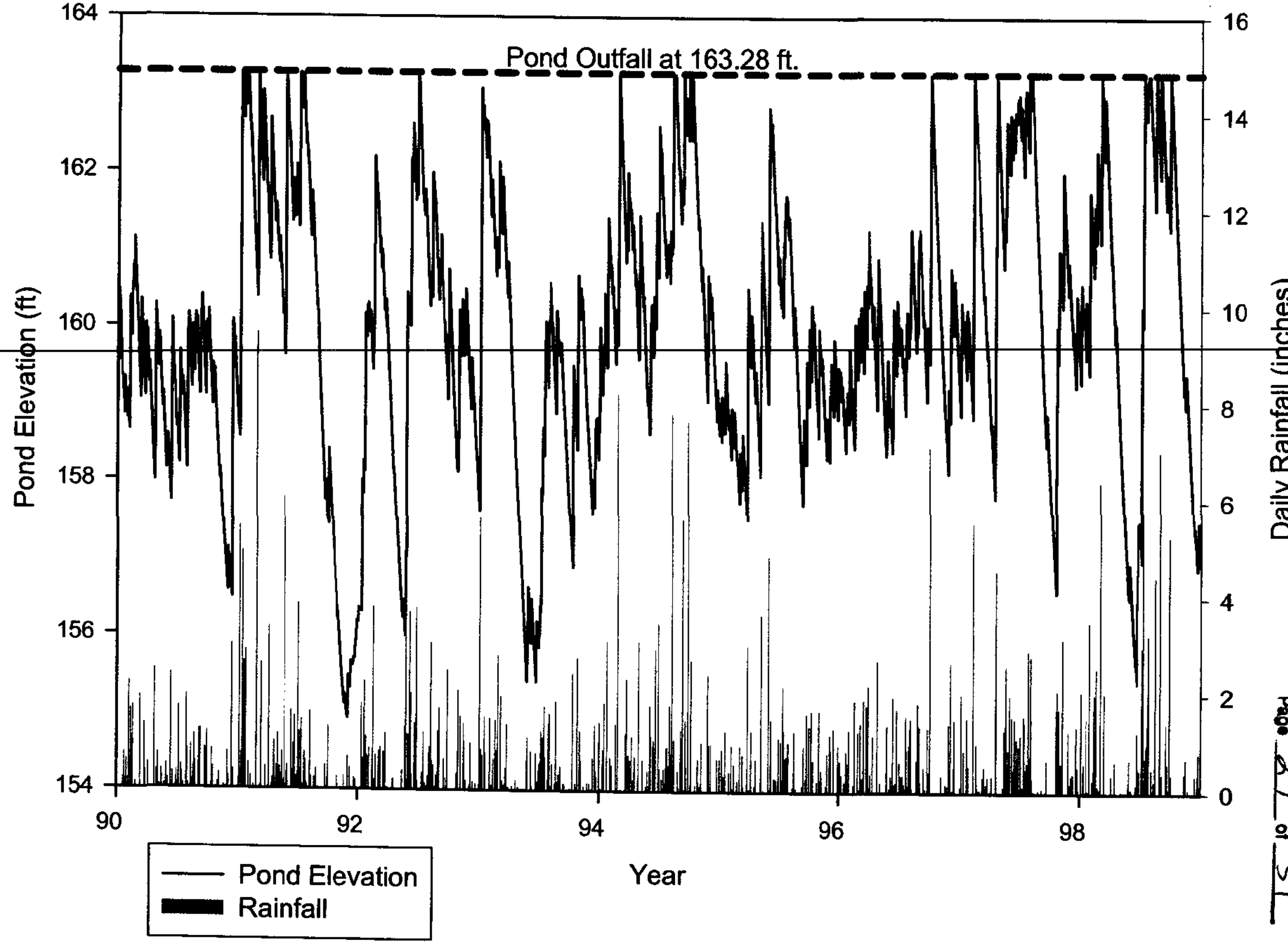

Figure 2-6. Model Simulated Water Elevations for SWMF No. 4 from 1990 to 1998.

model assumes that the remaining runoff generated during the rain event discharges directly through the outflow weir. Based upon the model simulation, discharges from the pond will occur to Lake McBride approximately 134 times during the 40-year period of record, or approximately 3.35 discharge events each year. A summary of pond and hydrologic conditions for each modeled overflow event, based upon future built-out conditions, is given in Table 2-6.

A summary of event characteristics resulting in overflow conditions is given in Table 2-7. Information is provided for daily rain occurring on the date of discharge as well as cumulative rain occurring at the site during the previous 14 days. Based upon this analysis, rain events resulting in overflow conditions range from 0.58 to 13.78 inches on the overflow date, with an overall mean of 3.97 inches. It appears that daily rainfall conditions necessary to cause overflow from the pond are quite variable and highly dependent upon the pond stage at the time of the rain event. Cumulative rainfall over the previous 14-day period creating overflow events ranges from 3.82 to 18.41 inches, with a mean 14-day cumulative rainfall of 8.61 inches required to create overflow conditions. Overflow conditions appear much more related to the 14-day cumulative rainfall than to rainfall occurring on the date of the overflow event. Runoff volumes discharging from the pond under overflow conditions are also highly variable, ranging from 0.10 to 87.03 ac-ft. The mean discharge event over the 40-year simulation period is 10.47 ac-ft.

TABLE 2-6

POND AND HYDROLOGIC CONDITIONS FOR OVERFLOW EVENTS UNDER FUTURE BUILD-OUT CONDITIONS

DATE	RAIN EVENT (inches)	14-DAY RAINFALL (inches)	MIN. 14-DAY POND ELEVATION (ft)	MAX. 14-DAY POND ELEVATION (ft)	MEAN 14-DAY POND ELEVATION (ft)	PREVIOUS DAY POND ELEVATION (ft)	OVERFLOW VOLUME (ac-ft)
3/14/1959	4.36	10.38	159.53	163.27	161.72	162.39	15.33
3/31/1962	7.15	7.62	157.68	158.43	158.09	157.68	12.16
2/27/1964	5.59	9.54	161.05	162.49	161.86	161.89	21.48
7/17/1964	9.73	11.67	161.51	162.44	161.96	161.51	57.12
7/26/1964	2.23	15.01	161.51	163.27	162.58	163.06	5.96
8/12/1964	2.23	7.55	162.56	163.27	162.92	163.16	6.77
9/10/1964	6.07	6.48	161.04	162.27	161.63	161.04	18.79
10/13/1964	6.27	10.49	161.05	163.27	162.32	162.29	30.84
12/3/1964	9.75	11.73	160.18	160.99	160.52	160.25	47.44
6/14/1965	5.97	10.33	158.18	161.93	159.67	161.51	21.70
6/16/1965	1.54	11.87	158.18	163.27	160.29	163.15	3.16
6/9/1966	6.88	7.35	160.17	161.34	160.80	160.17	19.45
7/22/1969	1.17	12.66	160.25	163.27	161.34	163.27	2.64
7/24/1969	1.10	12.98	160.25	163.27	161.74	163.15	1.42
9/20/1969	13.78	14.72	159.88	161.00	160.41	160.11	87.03
7/21/1970	8.17	13.38	160.01	161.35	160.79	160.93	37.30
6/18/1972	7.13	7.35	159.48	160.68	160.07	159.48	17.85
3/30/1973	7.04	11.32	160.71	161.99	161.25	161.89	34.47
4/3/1973	4.70	15.52	160.71	163.27	161.80	162.93	22.61
4/6/1973	2.89	18.41	160.71	163.27	162.25	163.04	9.88
9/4/1974	6.30	9.31	161.11	161.68	161.46	161.11	21.37
7/28/1975	8.91	12.52	161.41	161.82	161.58	161.51	49.10
10/7/1976	6.00	9.89	159.18	161.21	159.61	161.21	19.56
7/23/1979	3.62	14.18	159.31	163.27	162.54	162.59	11.31
7/23/1980	7.20	9.23	159.00	160.04	159.54	159.69	19.19
12/12/1985	5.07	7.05	161.81	162.82	162.35	161.81	16.39
8/12/1987	6.71	8.07	160.68	161.62	161.22	160.68	21.86
3/3/1988	5.55	5.55	161.90	163.27	162.58	161.90	21.22
1/19/1991	4.92	11.30	158.44	163.21	161.35	162.63	21.98
1/24/1991	2.63	8.29	162.63	163.27	162.96	162.84	6.62
1/27/1991	2.04	10.33	162.63	163.27	162.97	163.06	4.90
1/29/1991	2.88	12.47	162.63	163.27	163.02	163.16	10.92
3/2/1991	9.46	9.53	160.42	161.65	161.03	160.42	45.87
3/1/1994	8.21	9.59	159.53	160.25	159.92	159.78	28.92
8/14/1994	7.81	11.24	160.79	161.45	161.16	161.25	36.44
9/15/1994	5.61	8.13	161.37	162.08	161.73	161.63	19.52
10/1/1994	7.65	9.90	162.42	163.05	162.76	162.42	44.64
10/6/1996	7.13	8.87	159.07	160.03	159.59	159.58	18.19
3/7/1998	6.40	9.19	161.13	162.32	161.69	161.15	22.62
7/28/1998	3.23	8.55	162.70	163.27	163.01	163.27	14.16
7/30/1998	1.81	10.34	162.70	163.27	163.02	163.15	4.44
8/18/1998	4.45	5.34	161.55	162.70	162.15	161.55	9.11
8/19/1998	0.58	5.92	161.55	163.27	162.19	163.27	0.69

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TABLE 2-6 -- CONTINUED

DATE	RAIN EVENT (inches)	14-DAY RAINFALL (inches)	MIN. 14-DAY POND ELEVATION (ft)	MAX. 14-DAY POND ELEVATION (ft)	MEAN 14-DAY POND ELEVATION (ft)	PREVIOUS DAY POND ELEVATION (ft)	OVERFLOW VOLUME (ac-ft)
9/1/1998	7.04	7.63	161.95	163.27	162.65	161.95	34.96
9/29/1998	5.29	7.39	161.30	162.01	161.70	161.30	14.07
3/5/1959	5.98	8.06	159.09	160.27	159.69	159.53	7.70
6/1/1959	3.22	6.93	162.31	162.76	162.52	162.58	8.31
6/2/1959	1.90	8.83	162.31	163.27	162.55	163.27	5.88
10/9/1959	3.21	7.48	160.45	163.06	161.37	162.84	10.44
4/2/1960	6.29	7.30	159.70	160.55	160.08	159.81	11.34
9/28/1960	2.02	9.08	158.54	162.96	160.73	162.62	1.15
10/6/1960	2.18	9.02	159.65	163.27	162.40	162.50	1.05
8/29/1961	5.21	7.39	158.94	159.86	159.38	159.86	2.16
1/16/1964	2.55	8.20	160.80	163.22	162.33	162.80	5.74
7/23/1964	1.49	13.07	161.51	163.27	162.32	162.96	1.29
8/10/1964	1.54	5.44	162.56	163.20	162.91	163.05	2.27
10/3/1964	3.85	4.22	161.05	162.27	161.62	161.05	0.37
3/1/1965	4.20	6.27	162.36	163.01	162.69	162.36	13.82
7/12/1965	4.24	6.19	161.04	162.10	161.53	161.43	6.46
9/3/1965	3.93	5.64	161.36	162.09	161.69	161.40	3.86
9/27/1965	3.38	5.21	161.47	162.33	162.00	161.47	0.29
10/6/1965	2.85	7.76	161.47	163.27	162.58	162.78	7.50
3/4/1966	2.67	6.63	161.84	163.08	162.40	162.76	6.10
8/8/1966	4.21	8.60	160.82	161.60	161.17	161.50	6.83
9/18/1966	5.72	7.98	159.94	160.73	160.36	160.38	10.64
9/27/1966	2.45	10.20	159.94	163.27	161.92	162.42	1.90
9/8/1968	6.52	8.54	157.86	159.31	158.71	158.32	8.55
7/21/1969	4.67	12.60	159.86	162.42	161.10	162.31	17.16
7/29/1969	1.38	11.07	161.99	163.27	162.77	163.09	1.91
3/27/1970	3.49	5.24	161.86	162.64	162.26	161.86	4.31
8/6/1971	1.54	10.22	160.06	162.90	161.79	162.79	0.10
8/7/1971	1.45	11.59	160.06	163.27	162.02	163.27	3.75
6/24/1972	1.78	9.13	159.48	163.27	161.16	162.69	0.45
7/1/1972	1.32	12.18	159.48	163.27	162.77	163.24	2.97
2/8/1973	3.21	8.49	160.41	162.56	161.41	161.95	3.02
4/25/1973	3.82	3.82	161.31	162.70	161.99	161.31	2.22
5/8/1973	2.83	6.65	161.31	163.27	162.50	161.93	0.22
5/29/1973	1.58	5.53	161.57	163.22	162.21	162.99	1.96
4/8/1975	4.88	5.28	160.22	161.42	160.81	160.22	2.28
1/26/1976	3.80	3.88	161.08	162.32	161.69	161.08	0.25
5/22/1976	5.10	7.80	158.71	160.19	159.48	159.64	0.53
5/27/1976	1.80	9.61	158.81	163.27	161.00	162.94	2.63
6/1/1976	1.70	9.15	159.64	163.27	162.13	162.82	1.13
6/3/1976	1.65	10.80	159.64	163.27	162.60	163.15	3.66
6/27/1976	2.62	6.52	161.83	163.06	162.42	162.30	1.93
6/28/1976	0.73	7.25	161.83	163.27	162.50	163.27	1.17
6/29/1976	1.48	8.73	161.83	163.27	162.58	163.27	3.87
11/27/1976	4.97	9.70	160.45	161.75	161.22	161.17	10.35
11/28/1976	0.66	9.40	160.64	163.27	161.42	163.27	1.00

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TABLE 2-6 – CONTINUED

DATE	RAIN EVENT (inches)	14-DAY RAINFALL (inches)	MIN. 14-DAY POND ELEVATION (ft)	MAX. 14-DAY POND ELEVATION (ft)	MEAN 14-DAY POND ELEVATION (ft)	PREVIOUS DAY POND ELEVATION (ft)	OVERFLOW VOLUME (ac-ft)
8/14/1978	1.76	6.05	162.12	162.74	162.43	162.71	0.49
5/7/1979	5.74	9.95	160.64	162.48	161.80	161.51	19.69
7/11/1979	5.36	8.36	159.14	160.62	159.59	160.62	9.42
7/16/1979	2.89	11.25	159.14	163.27	160.77	162.81	7.97
9/24/1979	5.67	8.54	160.46	161.25	160.91	160.95	14.57
2/10/1981	6.04	8.53	157.03	158.22	157.63	157.98	3.20
3/4/1981	5.36	5.41	161.17	162.46	161.81	161.17	13.61
6/16/1982	5.82	5.87	158.09	159.27	158.67	158.09	1.62
3/6/1983	2.61	7.51	159.89	162.18	160.43	162.18	0.90
3/16/1983	2.20	8.92	159.89	163.27	162.14	162.38	0.12
3/20/1983	1.31	3.85	162.38	163.27	162.87	162.93	0.36
3/27/1983	1.89	6.10	162.38	163.27	162.89	162.71	1.17
4/7/1983	4.22	6.84	162.37	163.27	162.85	162.37	14.08
4/3/1984	3.86	6.28	161.43	162.31	161.84	161.69	5.60
4/8/1984	3.23	9.23	161.43	163.27	162.30	162.81	10.30
10/29/1985	7.17	7.97	157.77	158.54	158.15	157.96	13.28
11/20/1985	4.13	4.13	161.26	162.56	161.90	161.26	4.28
2/9/1986	3.84	8.21	159.36	161.58	160.21	161.49	3.87
7/23/1986	2.35	8.45	161.48	162.70	162.03	162.60	2.76
8/11/1986	2.24	5.49	162.27	162.89	162.59	162.45	0.95
8/20/1986	3.30	5.74	162.38	163.27	162.77	162.38	7.23
8/28/1986	1.48	6.04	162.38	163.27	162.81	162.90	0.81
9/1/1986	1.52	7.54	162.38	163.27	162.90	162.93	1.19
9/2/1986	1.32	8.78	162.38	163.27	162.96	163.27	3.23
12/9/1986	3.99	8.65	160.40	162.67	161.89	161.57	5.69
6/23/1987	1.97	10.36	159.49	163.04	161.61	162.93	3.42
6/25/1987	0.90	11.36	159.49	163.27	162.11	163.16	0.83
7/5/1987	1.84	5.95	162.48	163.27	162.91	162.62	0.11
2/18/1988	6.06	6.97	157.63	158.32	157.96	157.76	2.65
6/18/1989	4.58	12.46	159.99	162.50	161.62	162.28	16.22
7/1/1989	0.88	9.13	162.28	163.27	162.89	163.24	1.41
7/4/1989	2.36	6.56	162.52	163.27	162.95	163.11	7.10
5/26/1991	6.03	7.09	159.87	160.83	160.35	159.87	9.24
7/6/1991	3.83	7.43	161.34	162.12	161.67	161.34	2.58
7/7/1991	0.60	7.10	161.34	163.27	161.81	163.27	0.74
7/10/1991	1.18	6.33	161.34	163.27	162.13	163.04	0.76
6/28/1992	3.75	5.49	161.52	162.37	161.88	161.59	4.03
6/29/1992	2.24	7.73	161.52	163.27	161.94	163.27	7.75
8/20/1994	1.05	12.88	160.79	163.27	162.03	163.04	0.36
10/10/1994	2.70	10.51	162.42	163.27	162.76	162.42	3.48
2/13/1997	5.56	5.58	158.78	160.02	159.36	158.78	1.64
4/25/1997	4.56	8.04	157.90	161.11	158.76	161.00	5.60
7/31/1997	2.91	6.70	162.40	163.19	162.81	162.40	4.70
8/7/1997	2.79	7.30	162.40	163.27	162.85	162.84	7.61
8/8/1997	1.52	8.82	162.40	163.27	162.88	163.27	4.06 25
7/13/1998	5.79	9.42	157.21	160.40	158.28	160.13	9.36
7/27/1998	1.39	5.32	162.70	163.27	163.01	163.12	2.20

TABLE 2-7

CHARACTERISTICS OF MODELED OVERFLOW EVENTS UNDER BUILT-OUT CONDITIONS

PARAMETER		DAILY RAINFALL (inches)	14-DAY CUMULATIVE RAINFALL (inches)	OVERFLOW VOLUME (ac-ft)
Minimum Value		0.58	3.82	0.10
Maximum Value		13.78	18.41	87.03
Mean Value		3.97	8.61	10.47

A summary of estimated pond performance efficiency from 1959 to 1998, based upon the revised ERD model, is given in Table 2-8. Over this period, approximately 9696 ac-ft of runoff will enter SWMF No. 4. Approximately 7381 ac-ft of runoff will infiltrate through the pond bottom, with an additional 895 ac-ft lost to evaporation processes. The estimated volume discharged from the pond to Lake McBride is 1424 ac-ft. Over the 40-year period of the evaluation, approximately 85.3% of the runoff inputs into the pond will be retained and evacuated due to the combined processes of infiltration and evaporation.

TABLE 2-8

ESTIMATED POND PERFORMANCE EFFICIENCY FROM 1958-1998

PARAMETER	VALUE
Runoff Volume	9696 ac-ft
Infiltration Volume	7381 ac-ft
Evaporation Volume	895 ac-ft
Discharge Volume	1424 ac-ft
Number of Overflow Events	136
Overall Retention	85.3%

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Based upon the Bradfordville 4-inch Retention Standard, approximately 75.6% of the runoff inputs into the pond would need to be retained to meet the retention standard. Since the pond is estimated to provide a long-term retention of approximately 85.3%, SWMF No. 4 meets the 4-inch Standard outlined by the Bradfordville Stormwater Study. The pond appears to meet the performance standards even though a number of conservative assumptions were utilized in the analysis for generation of runoff volumes and for estimation of land use characteristics within the basin.

2.2 Long-Term Monitoring Plan

Leon County has proposed a long-term monitoring plan to monitor the performance efficiency of SWMF No. 4 with respect to volumetric recovery rates to ensure that the design operation is maintained throughout the life of the pond. To assist in this evaluation, the County proposes to install and regularly service an automated tipping bucket rain gauge to accurately determine rainfall volumes which occur in the SWMF No. 4 basin. The County also proposes to install a staff gauge in SWMF No. 4, referenced to NGVD datum, which will be routinely monitored to determine the pond elevation under various conditions. Records of water level elevation on the staff gauge would be performed before and after storm events to provide information on both the volume of runoff entering the pond from an individual storm, as well as the rate of volumetric recovery during the following inter-event dry period. The observed volumetric rates of recovery would be compared with the minimum volumetric rate of recovery necessary to assure adequate performance of SWMF No. 4.

The monitoring plan proposed by Leon County appears to contain the minimum elements necessary to assess the performance of SWMF No. 4 under a variety of storm event and inter-event dry period conditions. However, it is strongly recommended that a permanently installed 25 water level recorder be utilized in addition to the permanent staff gauge to assist in estimating runoff input volumes and pond drawdown. The use of a sensitive water level recorder would provide information in digital format which could be easily manipulated to obtain information necessary to evaluate the pond performance. Utilization of a staff gauge for estimation of pond volumes is less accurate and is subject to error by personnel performing the actual readings.

ERD routinely uses water level recorders and loggers, such as those manufactured by Global Water Instruments, Inc., to provide accurate and reliable water level measurements. These products contain a data logger coupled to a submersible pressure transducer for remote monitoring and recording of water level, flow, or pressure data. The submersible transducers are highly reliable and accurate and can log up to 24,400 readings between download events. A range of 0–15 ft is recommended for use in the SWMF No. 4 which would correspond to Global Water Model WL15. The WL15's data logger is housed in a water-resistant cylindrical enclosure that fits inside a 2-inch pipe. The data logger is connected to a laptop computer, using software provided by Global Water, and programmed for the site-specific conditions and data requirements. The data is downloaded into a standard spreadsheet format which can be easily manipulated to evaluate pond performance. This improvement in the monitoring program recommended by the County would provide not only additional accuracy but would also save time and efforts by eliminating the need to routinely visit the pond to record staff gauge readings. The current price for a Global Water WL15 water level logger is $795. Product information for the Global Water WL15 data logger is given in Appendix B.

SECTION 3

METHODS TO ENSURE AND ENHANCE POND PERFORMANCE

Although the modeling summarized in Task 2 indicates that SWMF No. 4 will meet the requirements of the Bradfordville 4-Inch Standard and the Leon County Land Development Code, the possibility exists that the recovery rate of the facility may slowly decline over time as a result of collection of fine soils and siltation over the bottom of the pond. As a result, a plan has been developed by ERD to evaluate the pond recovery rate and activate pond maintenance procedures. In addition, options are also evaluated for increasing the performance of SMWF No. 4 in the future in the event that the monitored performance of the system fails to meet the Bradfordville Stormwater Standard. The results of these analyses are discussed in the following sections.

3.1 Recommended Trigger Maintenance Mechanism

The performance efficiency of SWMF No. 4 is regulated primarily by the ability of the pond to infiltrate retained water into groundwater, with the remaining water volume lost by evaporation. As seen in Table 2-8, approximately 8294 ac-ft of water are evacuated from the pond over the 40-year simulation period through the combined processes of infiltration and evaporation. Of this retained volume, approximately 89% is lost as a result of infiltration through the pond bottom. Therefore, the ability of the pond to maintain adequate infiltration is essential for maintaining the desired performance of the pond.

As discussed in Section 2, the modified ERD model resulted in a simulated performance efficiency of approximately 85.5% for SMWF No. 4 over the period from 1958 to 1998. During this period, the mean infiltration rate through the pond bottom is 0.500 inches per day. To evaluate the effects of infiltration on pond performance, the average infiltration rate within the model was reduced sequentially until the performance of the pond was reduced to the minimum allowable retention volume of 76% required to meet the Bradfordville 4-Inch Rule. The performance of the pond is reduced to the minimum acceptable value when the mean infiltration rate is reduced from 0.500 inches per day to 0.439 inches per day, a reduction of approximately 12%. This degree of loss of infiltration is difficult to document, particularly if manual methods are used to record and evaluate data. The recommended water level recorder will be invaluable for assisting and evaluating potential decreases in pond infiltration.

To provide a degree of safety to ensure overall system performance, the trigger mechanism for maintenance procedures should be set to begin when the infiltration rate of the pond is reduced by approximately 6%, equal to 50% of the maximum allowable reduction. In other words, maintenance procedures should be initiated when the mean pond infiltration rate decreases from 0.5 inches per day to 0.47 inches per day. Detection of this level of decrease in system performance will be difficult at best, and will require constant evaluation of performance efficiency data for the pond.

In most cases, the infiltration capacity of a retention pond can be restored by scarification of the bottom material during dry periods using ordinary farm equipment. If the bottom of the pond has become covered with fine silt material which is restricting the infiltration through the bottom, sediment removal may be required. After the remediation process has been completed, field testing should be performed by a registered geotechnical engineer to verify that the mean infiltration rate is equal to 0.50 inch/day or greater.

3.2 Modifications to Enhance the Performance Efficiency of SWMF No. 4

As requested by Leon County, ERD has performed supplemental evaluations of the increased performance efficiency of SWMF No. 4 resulting from a variety of implemented pond modifications. A summary of the proposed pond modifications evaluated by ERD is given in Table 3-1. A total of four separate primary options were requested by Leon County. The first option (Option 1) consists of irrigation of the non-wetted side slopes and berms surrounding the pond (4.19 acres), plus the 1.50-acre pond enhancement area, at a rate of 1.5 inches per week. The second modeled option (Option 2) includes irrigation of newly constructed pervious areas in the drainage basin discharging to SWMF No. 4. These areas include the 52.8 acres of pervious acres planned for Area 1, as indicated in Table 2-2, along with the 3.59 acres of pervious area planned for the commercial lots, identified as Area 2B in Table 2-2. For purposes of this evaluation, these areas are assumed to be irrigated at a rate of 0.5 inch per week. Separate evaluations are conducted for irrigation intake elevations of 154, 157, and 160 feet, NGVD.

The third performance enhancement option (Option 3) involves planting of a shallow littoral zone around the pond perimeter. This option involves additional loss of water by evapotranspiration from the planted littoral zone. Two separate sub-options are evaluated, including littoral zone coverage over 20% of the pond area and littoral zone coverage over 30% of the pond area. The fourth performance enhancement option (Option 4) involves increasing the retention capacity of the pond by raising the outfall elevation. Separate evaluations are performed to evaluate outfall elevations at 164.0, 164.5, and 165.0 feet NGVD. The final performance enhancement option (Option 5) includes a combination of previously discussed enhancement options. Option 5 includes irrigation of pervious areas at a rate of 0.5 inch/week, with the irrigation intake set at elevation 157 feet (Option 2B), plus planting of a littoral zone over 30% of the pond area (Option 3B), and raising the outfall elevation to elevation 164.0 ft (Option 4A).

Attachment # 1
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TABLE 3-1

MODELED PERFORMANCE EFFICIENCIES OF POND ENHANCEMENT OPTIONS FOR SWMF NO. 4

OPTION	DESCRIPTION
1	Irrigation of the non-wetted side slopes and berms surrounding the pond (4.19 acres) plus the 1.50-acre pond enhancement area at 1.5 inches/week
2	Irrigation of the pervious areas in Area 1 (Table 2-3) plus the new commercial area (2B in Table 2-3) at a rate of 0.5 inch/week A. Irrigation intake at El. 154 ft B. Irrigation intake at El. 157 ft C. Irrigation intake at El. 160 ft
3	Planting of shallow littoral zones around pond perimeter (water loss by evapotranspiration) A. Littoral zone over 20% of pond area B. Littoral zone over 30% of pond area
4	Increase retention by raising outfall elevation to: A. El. 164.0 ft B. El. 164.5 ft C. El. 165.0 ft
5	Combination of options, including: A. Irrigation of pervious areas (0.5 inch/week) with intake at El. 157.0 ft (Option 2B) B. Planting of littoral zone over 30% of pond area (Option 3B) C. Raise outfall elevation to El. 164.0 ft (Option 4A)

Each of the options outlined on Table 3-1 were evaluated using the modified ERD model summarized in Section 2. Additional columns were added to the basic model to include losses as a result of irrigation or evapotranspiration by littoral zone plants. Similar to the model summary provided in Section 2, significant water losses from the pond are assumed to occur as a result of infiltration, surface evaporation, and discharges through the outfall structure.

A summary of the results of models performed by ERD is given in Table 3-2 for each of the proposed pond enhancement options listed in Table 3-1. Information is provided for the 25

TABLE 3-2

SUMMARY OF PERFORMANCE EFFICIENCIES OF EVALUATED POND MODIFICATION ALTERNATIVES

OPTION NUMBER	OPTION DESCRIPTION	RUNOFF VOLUME (ac-ft)	INFILTRATION VOLUME (ac-ft)	EVAPORATION VOLUME (ac-ft)	IRRIGATION VOLUME (ac-ft)	NUMBER OF DISCHARGE DAYS	DISCHARGE VOLUME (ac-ft)	PERCENT RETAINED
-	Existing	9696	7381	895	0	136	1424	85.3
1	Side Slope Irrigation	9586	6357	807	1291	102	1137	88.2
2A	Irrigation El. 154 ft	9367	3787	603	4358	58	635	93.4
2B	Irrigation El. 157 ft	9415	4878	681	3120	64	743	92.2
2C	Irrigation El. 160 ft	9528	6057	763	1754	79	959	90.0
3A	20% Littoral Zone	9659	7050	691	0	124	1299	86.6
3B	30% Littoral Zone	9645	6896	594	0	113	1244	87.1
4A	Increase Outfall to 164.0	9728	7705	922	0	102	1103	88.7
4B	Increase Outfall to 164.5	9744	7896	937	0	88	912	90.7
4C	Increase Outfall to 165.0	9763	8070	951	0	73	743	92.4
5	Basin irrigation set at 157, 30% littoral zone, and outfall raised to 164	9402	4757	470	2974	45	481	95.0

estimated runoff volume entering the pond, volume infiltrated through the pond bottom, evaporation volume, irrigation volume (if applicable), number of days of discharges, the estimated discharge volume, and the percentage of volume retained within the pond. It should be noted that estimated runoff volumes vary slightly between the different options depending upon the surface area of the pond for each option since the modified ERD model evaluates direct precipitation on the pond surface separately from the adjacent pervious areas. A summary of overflow events resulting in discharges from SWMF No. 4 for each of the evaluated options is given in Appendix C.

Irrigation of the non-wetted side slopes and berms surrounding the pond, identified as Option 1, will increase the performance efficiency of the pond from 85.3% to 88.2%. Irrigation of the pervious areas within the drainage basin, assuming a 56.39-acre area irrigated at a rate of 0.5 inch per week, will result in pond efficiencies ranging from 90.0% to 93.4%, depending upon the elevation of the irrigation intake. Planting of the littoral zone around the pond, either at 20% or 30% of the pond's surface area, will result in only slight improvement in pond performance, with efficiencies ranging from 86.6% to 87.1%. Increasing the outfall elevation will provide relatively significant improvements in Pond performance, with an estimated performance efficiency of 88.7% at an outfall elevation of 164.0 ft, 90.7% at an outfall elevation of 164.5 ft, and 92.4.% at an outfall elevation of 165.0 ft.

An alternative was also evaluated (Option 5) which includes irrigation of 56.39 acres of pervious areas within the basin with the irrigation intake set at an elevation of 157, planting of a 30% littoral zone around the pond, and raising the pond outfall to an elevation of 164 feet. Implementation of this option will result in approximately 95.0% of the runoff inputs into the pond being retained with approximately one day of discharge from the pond each year.

Based upon the summary presented in Table 3-2, performance of the pond could be enhanced most effectively by either raising the outfall elevation or providing irrigation for newly developed pervious areas within the watershed. Raising the outfall elevation may be the least expensive modification which could increase the performance efficiency of the system to more than 90%.

An additional alternative which could potentially enhance the retention capacity of SWMF No. 4 is to provide a series of conduits which would connect the bottom of the pond with deeper, more permeable layers beneath the pond. These conduits would consist of 12- to 24-inch bore holes which would be constructed into the bottom of the pond into a sandy permeable layer beneath the pond. The depth of these holes would depend upon the subsurface geology beneath the pond. Once a more permeable layer is encountered, the bore hole would be filled with coarse sand to maintain a permeable connection between the pond and the subsurface layer. This type of pond modification has the potential to significantly increase the retention capacity of the system, providing further assurances that the pond would continue to meet the Bradfordville Stormwater Rule. This type of modification has been used by ERD in previous projects to enhance the retention efficiency of ponds constructed in low permeability soils. Since a detailed evaluation of this alternative is beyond the scope of services for this project, additional geotechnical investigations would need to be conducted to evaluate the potential feasibility of this option.

SECTION 4

EMERGENCY MEASURES TO AVOID NON-COMPLIANCE

At the request of Leon County, ERD performed an evaluation of several emergency contingency measures that could be rapidly implemented to avoid violations of the Water Quality Provisions of the Leon County Land and Development Code as a result of discharges from SWMF No. 4. The measures evaluated include recovery of the storage volume in SWMF No. 4 by controlled releases of water from the pond to Lake McBride, as well as utilization of temporary pumps and piping on an emergency basis to transfer water from SWMF No.4 to other adjacent basins. A discussion of these options is given in the following sections.

4.1 Transfer of Water to Lake McBride

The first option involves the recovery of the storage volume in SWMF No.4 by controlled releases of water from the pond to Lake McBride when, and if, the water quality in the pond meets or exceeds the water quality in Lake McBride. Releases of water from the pond to Lake McBride under this option could occur under two separate hydrologic conditions within the lake. First, the water level in Lake McBride could be at or above the control elevation for the lake, indicating that water is discharging from the lake on a continuous basis. Under this condition, inputs of water into Lake McBride will result in a corresponding increase in the volume of discharges through the outfall, although discharges through the outfall will probably occur at a slower rate than the inputs due to attenuation within the system. If the water quality within the pond is equal to the water quality in Lake McBride, no net change in water quality 25 characteristics will be observed in the lake. If the water quality within the pond is better than the water quality in Lake McBride, a slight improvement in water quality characteristics may actually be observed within the lake.

If the water level in Lake McBride is below the control elevation of the lake at the time when controlled releases of water were initiated, the water discharged to the lake would begin to accumulate until the outfall elevation is reached. Technically, under these conditions, the inputs of water to Lake McBride could be considered an additional mass loading to the lake even though the water which is pumped to the lake may be equal to or better than the water quality within Lake McBride. However, the corresponding increase in volumetric inputs into Lake McBride would create an increase in volume as well as mass which would result in no significant impact on the lake in terms of water column concentrations. However, if the lake was not simultaneously discharging, the resulting inputs of nutrients into the lake would represent a net mass loading to the system even though there would be little or no impact on concentrations of nutrients within the water column.

Prior to discharge of water from SWMF No. 4 to Lake McBride, a water quality monitoring program must be initiated to verify that the inputs of water will not result in a degradation of water quality characteristics within Lake McBride. A recommended monitoring program for release of SWMF No. 4 water to Lake McBride is given in Table 4-1. Monitoring should be conducted in both SWMF No. 4 and in Lake McBride. The monitoring performed in SWMF No. 4 should be conducted near the center of the pond with separate samples collected from the top, middle, and bottom layers of the water column. Field measurements of pH, dissolved oxygen, and conductivity should be performed at the monitoring location, with water samples collected for laboratory analyses of ammonia, NO_x, total nitrogen, orthophosphorus, total phosphorus, and TSS. Monitoring in Lake McBride should be performed at three separate locations to obtain information on overall water quality characteristics within the lake. Monitoring should be conducted in the middle of the south lobe, the middle portion of the lake, and the middle of the north lobe. Recommended monitoring sites in SWMF No. 4 and Lake McBride are indicated on Figure 4-1. Separate samples should be collected at each site at a depth equal to 50% of the Secchi Disk depth at each location. Parameters to be monitored would be identical to the parameters evaluated in SWMF No. 4. Analyses for the parameters outlined for SWMF No. 4 and Lake McBride could be completed in approximately 48 hours.

TABLE 4-1

RECOMMENDED MONITORING PROTOCOL FOR RELEASE OF SWMF NO. 4 WATER TO LAKE McBRIDE

MONITORING LOCATION	RECOMMENDED MONITORING	MONITORED PARAMETERS
SWMF No. 4 - Center of Pond (P-1)	Separate samples collected from top, middle, and bottom of water column	1. pH (field) 2. Dissolved Oxygen (field) 3. Conductivity (field) 4. Ammonia 5. Nitrite + Nitrate 6. Total N 7. Ortho-P 8. Total P 9. TSS
Lake McBride 1. Middle of south lobe (M-1) 2. Middle of lake (M-2) 3. Middle of north lobe (M-3)	Separate samples collected at 50% of Secchi Disk depth	1. pH (field) 2. Dissolved Oxygen (field) 3. Conductivity (field) 4. Ammonia 5. Nitrite + Nitrate 6. Total N 7. Ortho-P 8. Total P 9. TSS

Recommended acceptance criteria for discharge of water from SWMF No. 4 to Lake McBride is given in Table 4-2. The acceptance criteria listed for pH and dissolved oxygen reflect the Class III standards for these parameters outlined in Chapter 62-302 of the Florida

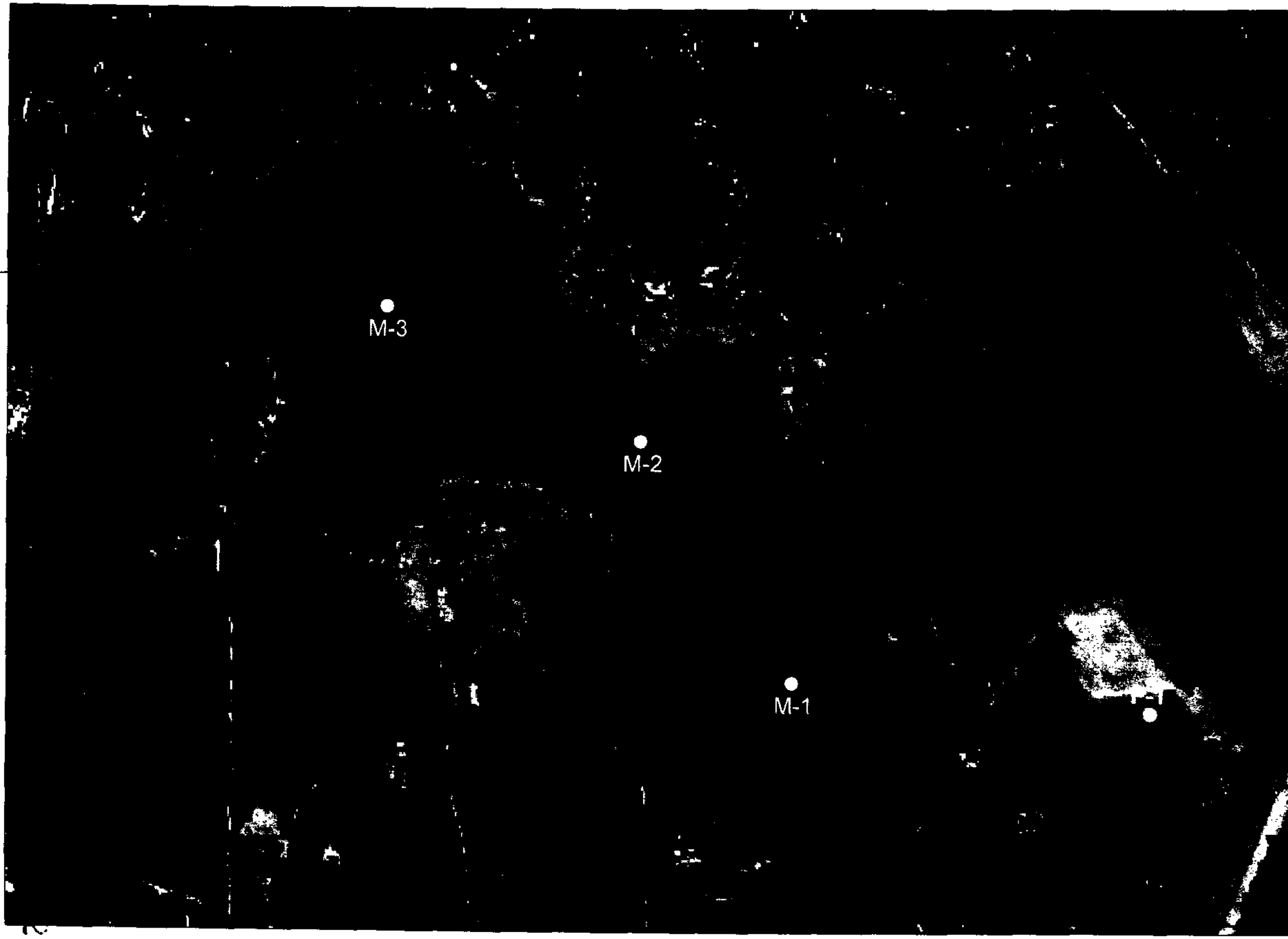

Figure 4-1. Recommended Monitoring Locations in SWMF No. 4 and Lake McBride.

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Administrative Code (FAC). In addition, the sum of concentrations of NH_3 plus NO_x in SWMF No. 4, representing biologically available inorganic nitrogen species, should not exceed the sum of these parameters in Lake McBride. Similarly, measured concentrations of total nitrogen, orthophosphorus, total phosphorus, and TSS in SWMF No. 4 should be less than or equal to the mean concentrations for these parameters measured in Lake McBride.

TABLE 4-2

ACCEPTANCE CRITERIA FOR DISCHARGE OF WATER FROM SWMF NO. 4 TO LAKE McBRIDE

PARAMETER	ACCEPTANCE CRITERIA FOR SWMF NO. 4 WATER
pH	$6.0 \le pH \le 8.5$
Dissolved oxygen	> 5 mg/l
$NH_3 + NO_x$	$\le NH_3 + NO_x$ in Lake McBride
Total N	≤ Total N in Lake McBride
Ortho-P	≤ Ortho-P in Lake McBride
Total P	≤ Total P in Lake McBride
TSS	≤ TSS in Lake McBride

During the release event, accurate records should be maintained of the volume of water discharged from SWMF No. 4 to Lake McBride. This information will be useful in the event of disputes over potential impacts within the lake. All laboratory analyses should be performed by a NELAP-certified laboratory, with field monitoring activities corresponding to the procedures outlined in DEP-QA-002/02.

4.2 Feasibility of Emergency Pumping

The final emergency measure evaluated by ERD is the use of temporary pumps and piping to transfer water from SWMF No. 4 southward along Thomasville Road to SWMF No. 3, which is located west of Kerry Forest Parkway approximately 6828 feet (1.3 miles) south of SWMF No. 4. The feasibility of pumping water from SWMF No. 4 to SWMF No. 3 depends to a large extent upon the volume of water to be pumped and the time period during which the pumping must be performed.

In order to pump water from SWMF No. 4 to SWMF No. 3, water would have to be transferred from SWMF No. 4 into the upstream portion of the stormsewer system which discharges to SWMF No. 3. The first structure in the stormsewer system discharging to SWMF No. 3 is identified as Curb Inlet S-132 which is located approximately 2228 feet south of SWMF No. 4. After entering structure S-132, the water would flow by gravity through the existing stormsewer system south to SWMF No. 3. In addition, water from SWMF No. 4 would have to be raised from the water surface elevation of approximately 160 feet to the top of the drainage divide between SWMF No. 3 and SWMF No. 4 at an elevation of approximately 193 feet, or approximately 33 feet higher in vertical elevation than the water surface of SWMF No. 4. Therefore, the pump would have to overcome a vertical head of approximately 33 feet plus the head loss during travel through 2228 feet of discharge line before entering the SWMF No. 3 system. A schematic of the drainage systems for SWMF No. 4 and SWMF No. 3 is given in Figure 4-2.

Hydrologic characteristics of the upstream portion of the stormsewer system discharging through SWMF No. 3 in the vicinity of structure S-132 were obtained from FDOT construction drawings for the widening of Thomasville Road. A summary of hydraulic characteristics of the upstream stormsewer system for SWMF No. 3 is given in Table 4-3. The most upstream

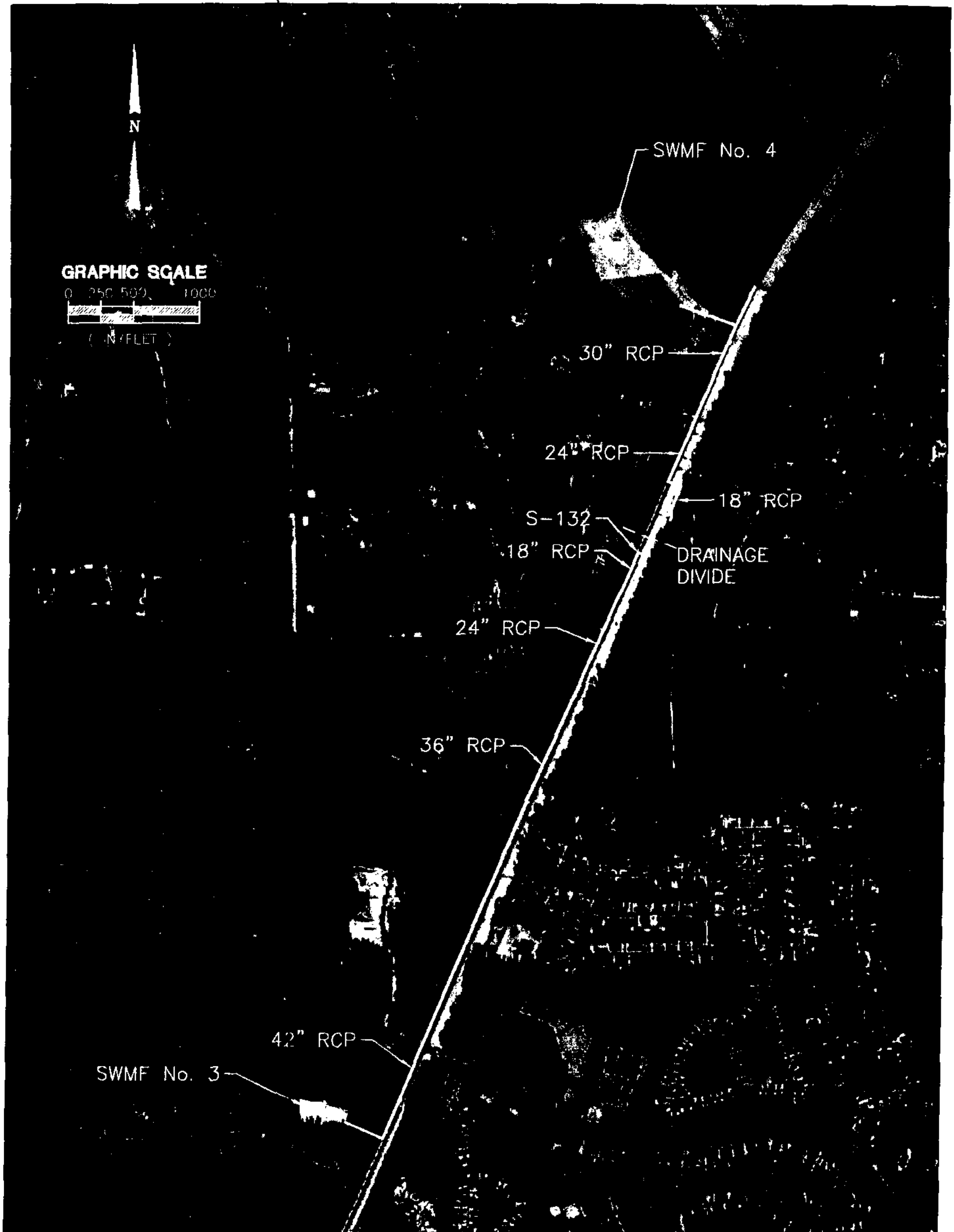

Figure 4-2. Schematic of the Drainage Systems for SWMF No. 4 and SWMF No. 3.

stormsewer pipe which initially discharges from structure S-132 is an 18-inch RCP stormsewer which is constructed on a slope of approximately 0.0147 ft/ft. Based upon these hydraulic characteristics, the Manning Equation predicts that the maximum flow capacity of the system in the vicinity of structure S-132 is approximately 12.68 cfs or 5690 gpm.

TABLE 4-3

HYDRAULIC CHARACTERISTICS OF THE UPSTREAM PORTION OF THE STORMSEWER SYSTEM DISCHARGING TO SWMF NO. 3

PARAMETER	VALUE
Stormsewer Diameter	18 inches
Pipe Material	RCP
Pipe Slope	0.0147 ft/ft
Maximum Flow Capacity	12.68 cfs 5690 gpm

For this scenario, it is assumed that the volume required to be pumped on an emergency basis would be equal to the modeled overflow volume for the pond during built-out conditions. As seen in Table 2-12, the mean overflow volume for the pond over the 40-year simulation period is approximately 10.45 ac-ft. Assuming a pumping period of 12 hours, the average pumping rate to evacuate a volume of 10.45 ac-ft in a 12-hour period is approximately 4730 gallons per minute or 10.5 cfs. Pumping of this volume could be achieved through a 16-inch PVC temporary pipeline at a mean flow velocity of 7.52 ft/sec.

Representatives of United Rentals, specialists in high capacity industrial and construction related pumps, were contacted to obtain estimates of the pump and piping requirements for transfer of approximately 5000 gallons per minute from SWMF No. 4 into the upstream stormsewer system for SWMF No. 3 based upon the previously described physical characteristics. A summary of pump and piping requirements for the proposed pumping option is given in Table 4-4 based upon information provided by United Rentals. Transfer of water from SWMF No. 4 at a nominal rate of 5000 gallons per minute will require a 12-inch John Deere "Power Tech" diesel pump or equivalent. The impeller diameter of the recommended pump is 15.5 inches. The pump discharge will occur into a 16-inch HDPE or PVC line which will extend approximately 2300 ft from SWMF No. 4 into Structure S-132. The estimated head loss over this distance is approximately 28.5 ft. Fuel consumption for this pump is estimated to be approximately 6.2 gallons of diesel fuel per hour. Over the proposed 12-hour pumping period, the diesel pump will consume approximately 75 gallons of fuel.

TABLE 4-4

PUMP AND PIPING REQUIREMENTS FOR PROPOSED PUMPING OPTION

PARAMETER	VALUE
Pump Size	12 inch
Pump Type	John Deere "Power Tech" Diesel
Impeller Diameter	15.5 inch
Pipe Size	2300 ft of 16-inch HDPE or PVC
Elevation Head	33 ft
Major Head Loss	28.5 ft
Total Dynamic Head	62 ft
Fuel Consumption	6.2 gph
Nominal Pumping Rate	5000 gpm

Set-up of the pumping system and discharge piping will be an extremely expensive and time-consuming operation. Placement and connection of the 2300 ft of 16-inch HDPE or PVC pipe is estimated at 4-5 days. This represents a relatively long lead time for a pumping operation which would be used under emergency conditions. Estimated labor costs for set-up of the pump and piping system is approximately $9000, with an additional $1000 per day for a fusion machine and technician if HDPE pipe is utilized. Tear-down of the system at the completion of the pumping process is estimated at $5000. Rental of the primary pump and piping, if not available through Leon County, is estimated to be approximately $13,700 per month which includes the pump, 2300 ft of 16-inch HDPE, and various suction pipe, fittings, and miscellaneous attachments.

Due to the expense and time required for set-up of the pumping operation, transfer of water from SWMF No. 4 to SWMF No. 3 does not appear to be feasible as an emergency measure for reducing the volume in SWMF No. 4. Set-up of the system will require approximately 4-5 days, at a minimum, with a large expense incurred for labor and rental costs. The long lead time required for this option substantially reduces the feasibility of temporary pumping as an emergency measure. For emergency transfer of water, it would be much easier and quicker to simply transfer water from SMWF No. 4 to Lake McBride, provided that the acceptance criteria for discharge of water to Lake McBride, outlined in Table 4-2, are met.